surface only periodically, in one or a few months of the year. This is probably dependent upon conditions of reproduction and development, as well as upon the temperature of the season. The daily variations are conditioned by the weather, and particularly by the wind and rain. A shower will very quickly reduce the specific gravity of the surface water and thus drive the surface-dwelling animals below. Many animals rise to the surface only at a definite time of day, some in the morning, others at noon, and yet others only towards evening.

Climatic Difference.—Prof. Haeckel thinks that the quantity of the Plankton is very little dependent upon the climatic difference of the zones, but that the quality is greatly so, and indeed in this way, that the number of component species diminishes from the equator to the poles. These conditions, he believes, are directly referable to the influence of the sun, "the omnipotent creator," whose more direct rays bring about an acceleration in the processes which make up the cycle of life. As this is true of the terrestrial fauna and flora so it is true of the marine.

Currentic Differences.—Conspicuous differences are also brought about by the numberless currents, great and small, by the little-known deep sea oceanic currents as well as by the better-known great surface currents, the Gulf Stream, the Falkland Stream, the Guinea Stream and others. These currents play a great *rôle* in the distribution of many forms of life. More local influences are exerted by the small currents whose causes are found in the climatic and geographical conditions of the adjacent coast. The relations of Plankton life to currents is little known, and needs investigation, but first a better knowledge of the currents themselves is necessary.

Almost every one who has seen the surface of the ocean in a calm has noticed the glassy areas of irregular shape. These are found on the high seas as well as in sheltered bays and harbours, and are of very special interest to the student of marine life. So far as made out they are extremely irregular in time and place of appearance, and the conditions governing them have not been carefully studied. They are in a measure influenced by winds and currents, by the ebb and flow of the tide. Here, into a limited space, are crowded great numbers of organic forms; this space is readily distinguished from the surrounding water in which there is comparatively little life. These phenomena have been noticed by seafaring men and have many different names in different countries.

A word in conclusion as to the bearing and importance of the Plankton in human economy in the near future. When Malthus promulgated his famous doctrine he failed to consider the final element which enters into the problem of human population, the human mind. The ingenuity of the human mind has brought about a decreased efficiency in the natural checks to undue increase, and thus an artificial increase in the food supply is rendered necessary for the crowding population. This food supply is now mainly derived from the cultivation of the land. A still further increase of population will necessitate a levy upon marine life. As soon as man to any great degree becomes a factor in the Plankton conditions by drawing from it large quantities of food, particularly in the form of mature animals, the equilibrium of oceanic life will be disturbed, and must be adjusted by artificial means. But further, a study of the phenomena of marine life shows that the water as well as the land, through cultivation, is capable of producing a greatly increased food supply for man. The necessity of cultivating the marine resources is even now apparent, and many governments have already begun to cope with the question by the establishment of commissions of fisheries. Of these commissions that of the United States stands in the front rank by virtue of its positive results. But in the near future individual attention must be turned to supplementing the terrestrial resources, the wheat fields, the cattle and sheep ranches, by an increasing utilization and development of the possibilities of marine farming; by fish propagation, by plantations of oysters, clams, quahaugs and scallops, by raising herds of lobsters and crabs. Improved breed of fish, of lobsters will result. The possibilities are well-nigh limitless; and by cultivation of the sea and sea bottom, as well as of the land, man will postpone indefinitely the fulfilment of the Malthusian prophecy.

But conditioning all advance in the possibilities of marine cultivation is the knowledge of the Plankton, of its distribution, and of the fundamental basis of marine life the microscopic marine organisms in the ocean.

GEORGE W. FIELD.

OPTICAL PROJECTION.[1]

THE intention of this lecture is to give a general survey of the subject of Optical Projection, which now takes its position in science, and to present examples of what may be done by this method. It would be difficult to determine which subject claims a first place. Some scientists say the microscope should have the preference, while others take a different view. For my own part, I think the microscope and polariscope stand foremost, on account of the facility with which these branches of science may be pursued for the benefit of a large number, without multiplying expensive apparatus; also because of the convenience in saving the eyes from undue strain. Indeed, to many persons, looking at objects in the table microscope is little short of a painful operation, and consequently the study of small objects becomes to them impossible. The projection method immediately brings the required relief.

For general instruction, projection methods are invaluable, such as, for instance, showing diagrams, photographs, and other slides, upon the screen; as well as for spectrum analysis. In fact, the subjects which can be illustrated by means of optical projection are innumerable; but time will allow me to present only a few examples, and I trust that, when I approach the end of my lecture, my view of the importance of this subject will be held in equal estimation by you.

Probably the only people in the world that benefit by the experience of their predecessors are those who pursue the study of science. They are free from the accusation of robbing the brains of other men, when they take up methods or apparatus already known and improve upon them or employ them for their own work. In such cases, however, it is always understood that honour should be given where honour is due, and accordingly I have no wish to represent to you any piece of apparatus as of my own devising, when in reality it belongs to another.

Few men have had a larger experience, and attained greater success in optical projection, than has Mr. Lewis Wright, who has embodied in his most recent forms of apparatus all that was good in designs existing until his time. I have, therefore, started from his models, making such modifications as I thought to be desirable. Mr. Wright does not appear—if I may say so —to have had much experience with the electric arc light as a radiant, and I found, at a very early stage, that great difficulties had to be encountered when this light was used, chiefly because the radiant approaches more nearly to what theory requires. That which was easy with the lime-light became almost impossible with the arc lamp, and these difficulties had to be conquered.

Many scientific men are dissatisfied with the projection microscope, on the ground that very high magnification does not give that resolution and that sharpness which is found in the usual methods of observation. This want I fully admit. At the same time it is scarcely right to condemn a particular method because you try to apply it to an unsuitable purpose. Hundreds of thousands of subjects may be shown with the projection microscope with far greater profit to the student than was possible in the old way. The very fact that the professor can place his pointer upon any part of the picture on the screen is invaluable to the students. I shall, therefore, attempt to show you only a series of microscopical subjects suitable for projection, and shall not employ very high magnification.

In regard to some substances very high powers may be used with advantage, but much time would be lost in getting them into the field and focussing them upon the screen. These, consequently, I omit, so that a large number of subjects may be illustrated.

It is fair to state that most of the apparatus used to-night has been constructed by Messrs. Newton, of Fleet-street, and the luminous pointer by Messrs. Steward, of the Strand. The arc lamp is a Brockie's projector. Messrs. Baker, Watson, and others have also come to my assistance.

I will first show, on the screen, a picture of the lantern carrying its various apparatus; and then a few systems of lenses, which may be employed for the projection microscope, as well as a diagram of the microscope itself.

Sub-stage condensers and objectives are, as a rule, made to suit the table microscope. When projecting, by means of an objective alone, in consequence of the screen distance being very great—or, in other words, the microscope tube being exceedingly long as compared with the table instrument—the objective has to be approached very close to the slide; in fact, with the higher powers, closer than the cover-glass will allow. This close working distance renders necessary special sub-stage condensers, and in many cases a special one is required for every screen distance with each objective. This requisite would seem to be a complete stumbling-block to microscope projection work. With the lime-light the difficulty does not enter in the same degree as with the arc light, and as we are now dealing with the latter, further reference need not be made to the oxy-hydrogen light. There are two ways of surmounting the difficulty; one by the use of plano-concave lenses, introduced in such a way as to be equivalent to greatly lengthening the focus of the objective on the screen side, while it enables, as a consequence, the objective to be slightly further removed from the slide, *i.e.*, giving what is termed a greater working distance. The objection to this method is that, even when these plano-concave lenses are corrected, the result, though greatly improved, is not perfect. The second way, which is a perfect one, is that of introducing an eye-piece. In both these methods, that the best results may be obtained, the objective is made to occupy a position not very different from that which it would do if employed on the table microscope.

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[1] Friday evening discourse delivered by Sir David Salomons at the Royal Institution, on February 26.

In the eye-piece method almost the exact conditions can be complied with for which the objective was made. I propose, therefore, to show the subjects by the eye-piece method. The only objectives which will be used are: (1) Zeiss's 35 millimetre projection objective, with a sub-stage condenser, 4 inches focal length, placed a considerable distance from the slide; (2) Newton's 1-inch projection objective, the sub-stage condenser as in the first case; and (3) Zeiss's $\frac{1}{4}$-inch achromatic objective, the sub-stage condenser being Prof. Abbé's three-lens condenser with the front lens removed. In all three cases the eye-pieces used are Zeiss Huyghens No. 2 and No. 3.

In each instance I will mention the magnification in diameters, as well as the number of times when reckoned by area, for the appreciation of those who estimate by area; and I will also give the size to which a penny postage stamp would be increased, supposing it to be made of india-rubber, and stretchable to any extent in all directions. In presenting these figures I do not pretend that they are absolutely correct, but as they have been ascertained under conditions similar to those now existing the errors will not be very great.

In consequence of the field not being quite flat, and the sections having a certain thickness, although extremely thin in most cases, the whole of the object cannot be in focue upon the screen at the same time. By shifting the focussing screw slightly all parts may be brought into focus successively. So-called greater depth of focus is obtained by using an increased working distance; and for projection work over-correction for flatness can alone give a sharp picture all over with very considerable depth of focus; the difficulty of over-correction being that, unless extreme care is taken, certain forms of distortion may be introduced. By stopping down the objective greater flatness of field may be secured, but at the expense of light. There is thus a choice of difficulties, and the least one should be taken.

Turning now to the polariscope. Polarized light teaches us a great deal concerning the structure of matter; it is also a means of confirming the undulatory theory of light. This subject is so large that no attempt can be made to give even a general idea of the field it covers, and the experiments, which will be shown in the polariscope, may be taken simply as a few illustrations of the subject and nothing more; but they will, at any rate, be suggestive of the large field to which this method of analysis can be applied. A vast amount of mathematical proof can be illustrated graphically by various experiments with polarized light. I will show on the screen a diagram of the polariscope. (Shown.)

With reference to showing the spectrum. The method of projecting a spectrum, I think, is new, as I have not seen it described anywhere. It gives practically a direct spectrum with an ordinary prism, without turning the lantern round to an angle with the screen; and here is a diagram of the method.

The details of the apparatus, as well as those of the methods of working, I have modified in almost every instance, for five reasons:—(1) That more certain results may be ensured; (2) that rapidity may be obtained; (3) that only one operator may be needed; (4) that, as far as possible, all parts of the apparatus may be interchangeable; and (5) that loose screws and pieces may be dispensed with.

There were then shown by projection a number of slides illustrating various microscopic optical systems, and a number of microscopic slides, followed by a series of general polariscopic projections, some of them to illustrate the strains existing in many forms of matter; also a spectrum by a carbon disulphide prism, in conjunction with a reflecting prism and with a mirror, which, apart from any other result, demonstrates that the loss of light with a reflecting prism is less than with an ordinary glass mirror. Slides and other projections were also thrown upon the screen.

The details are as follows:—

The Microscope.—Screen distance, 21 feet. First 35 millimetres Zeiss projection objective, 4-inch sub-stage condenser, Zeiss Huyghens eye-piece 2; 500 diameters = 250,000 times = penny stamp stretched to cover about 147 square yards. Subjects shown: proboscis of blowfly; permanent molar displacing milk-tooth (kitten); human scalp, vertical; human scalp, surface; fossil ammonites and belemnite. Second, 1-inch Newton's projection objective, 4-inch sub-stage condenser, Zeiss Huyghen's eye-piece 2; 1,000 diameters = 1,000,000 times = stamp stretched to about 588 square yards. Objects shown: proboscis of blow-fly; foot of a caterpillar; section of human skin, showing the sweat ducts; phylloxera vastatrix of the vine. Third, 1-inch Newton's projection objective, 4-inch sub-stage condenser, Zeiss Huyghens eye-piece 3; 1,300 diameters = 1,690,000 times = stamp stretched to about one-fifth of an acre. Slides shown: proboscis of blow-fly; wings of bee (showing hooklets and ridge); sting of bee (showing the two stings, sheath, and poison-sack); sting of wasp (showing same as last slide); eye of beetle (showing the facets). Fourth, $\frac{1}{4}$-inch Zeiss's achromatic objective; Abbé's 3-lens sub-stage condenser, with top lens removed; Zeiss Huyghens eye-piece 3; 4,500 diameters = 20,250,000 times = stamp extended to nearly $2\frac{1}{2}$ acres. Slides shown: proboscis of blow-fly; hair of reindeer (showing cell structure); hair of Indian bat (showing the peculiar funnel-like structure); sting of bee (showing the barbs); foot of spider; stage of the micrometer (the closest lines ruled to thousandth of an inch, which measure $4\frac{1}{2}$ inches apart under this magnification); a wave length $\frac{1}{40000}$ inch, therefore, on screen measures about $\frac{1}{9}$-inch.

The Polariscope.—Shown with parallel light: plain glass; glass under pressure; chilled glass (round, oval, and waved peripheries); Prince Rupert's drop (broken in the field); horn; selenites (over-lapped); butterfly (selenite); bunch of grapes (selenite); bi-quartz, with $\frac{1}{4}$-wave plate (the $\frac{1}{4}$-wave plate in this experiment produces the same effect upon the bi-quartz as if a column, 20 centimetres long, of a $7\frac{1}{2}$ per cent. solution of cane sugar were placed between the polarizing nicol and the bi-quartz. The analyser has to be rotated about 10°); a piece of sapphire to show asterism. Shown with convergent light; hemitrope (cut in a plane, not at right angles to the axis); ruby; topaz; grape sugar (diabetic); cane sugar; quartz; superposed right and left-handed quartz (spirals); calcite and phenakite superposed (showing transition from negative to positive crystal, passing through the apopholite stage).

The Solidiscope.—New form of apparatus for showing solids, and consisting of two reflecting prisms and suitable projecting lenses. With this instrument were shown:—Barton's button, the works of a watch, a coin.

Spectrum Analysis.—Spectrum thrown by means of a disulphide prism combined with a reflecting prism; the result being that a good spectrum is thrown upon the screen direct without turning the lantern. There were shown:—The spectrum; absorption bands of chlorophyll, &c.; effects produced by passing the light through coloured gelatine films.

Projection of Slides.—Decomposition of water; expansion of a wire by means of heat; combination of colours to form white light; various diagrams, coloured photographs of a workshop, &c. As an extra experiment there was shown, in the polariscope, with a convergent light, Mitscherlisch's experiment (illustrating the changes which take place in a selenite under the influence of heat).

There are but few who would disagree with me in the opinion that the microscopic world, as regards its design and its molecular structure, is quite as wonderful as the great works around us seen with the unaided eye. A magnifying glass of low power opens up a world far larger than that which we are accustomed to see. At the present time, even with the most perfect apparatus that exist, only a small portion of the universe is known to us.

Scientific study should be pursued by all in a greater or less degree. It teaches more important lessons than the most impressive discourse ever preached. During the investigation of what is generally termed the invisible world, men should at time pause to reflect, and ask themselves such questions as these: What is the meaning of, and to what end is, creation? Is it all mere chance? Were such wonderful designs and properties created at the beginning? Was there in matter at the beginning an inherent, or implanted, power of development? Simple as these questions may seem, man in the flesh will never be able to find the true answers. The extraordinary design and structure which have existed in the unseen world for millions of years, or possibly in all past time, and even at the present day known to so few, demonstrate at least that the great Power has bestowed the same care upon what appear to us the most insignificant portions of creation, as upon what we think are the greatest works in the universe. These silent sermons must surely influence the mind, and set it thinking of the supernatural and of our duties during life.

It may now with truth be said that science gives us means, such as never before existed, of appreciating the greatness of the Supreme Spirit, by enabling us to read fresh chapters in the book of nature.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Prof. Darwin has been appointed to represent the University at the approaching tercentenary of Galileo's appointment to a chair in the University of Padua. The celebration will take place in Padua at the beginning of December.

Prof. Green, of Oxford, is appointed an Elector to the Harkness University Scholarship in Geology in the place of the late Mr. T. Roberts, assistant to the Woodwardian Professor.

The discussion in the Senate of the proposal to found a mechanical sciences tripos for engineering students was unexpectedly favourable, in marked contrast to the reception accorded to former schemes. Prof. Ewing is to be congratulated on the skill with which the new plan has been framed, and the success with which he has met and conciliated the original opposition of the more mathematical members of the Senate. The grants for the approval of the plan have been sanctioned by the Council, and it is not likely that they will now be opposed. Some fifteen students are already at work in the engineering laboratary in preparation for the new tripos, which bids fair to take a good place among the honours schools, and cannot fail to stimulate the growth of the engineering department under its present energetic head.

DUBLIN.—At the meeting of Council of the Royal College of Science, Dublin, held on the 5th inst., a letter was read from H.M. Commissioners for the Exhibition of 1851, announcing that they had been pleased to place at the disposal of the College a science scholarship of the annual value of £150 for the year 1893. These scholarships are specially instituted for the encouragement of scientific research and are tenable for two years, and one of them has already been nominated to by the Council of the College for the year 1891-92.

SCIENTIFIC SERIALS.

American Journal of Science, October.—On a colour system, by O. N. Rood.—An ottrelite-bearing phase of a metamorphic conglomerate in the Green Mountains, by C. L. Whittle.—The age-coating in incandescent lamps, by E. L. Nichols. The diminution of efficiency in incandescent lamps is due to three causes, viz., loss of vacuum, increase of resistance due to the the disintegration of the filament, and finally the deposition of disintegrated carbon upon the inner surface of the lamp-bulb. This deposition gives rise to what is called the age-coating. It appears that the rate of deposit of the coating in incandescent lamp-bulbs is greatest in the early part of the life of the lamp. For example, in the case of a lamp which lasted 800 hours, more than half the coating was deposited during the first 200 hours. The loss of brightness due to the absorbing power of the age-coating is a variable part of the total loss, being greatest in lamps of high initial efficiency. The coating does not appreciably modify the character of the light transmitted, as shown by a series of photo-spectroscopic measurements. The distribution of the coating within the bulb is nearly uniform. No marked difference between treated and untreated filaments appears to exist as regards the coating produced from them. It has been pointed out, however, that in the case of lamps exhausted without the aid of mercury the age-coating is scarcely perceptible.—Mica-peridotite from Kentucky, by J. S. Diller.—Glaciation in the Finger Lake region of New York, by D. F. Lincoln.—Certain points in the interaction of potassium permanganate and sulphuric acid, by F. A. Gooch and E. W. Danner. When these two bodies are brought into solution together there is developed a tendency towards reduction on the part of the permanganate, which is the greater as the strength of the acid is increased, as the temperature is raised, and as the duration of the action is extended. At first, the oxygen lost to the permanganate is liberated, whereas in the later stages manganese is precipitated in the form of a higher oxide or retained in solution in the form of a higher sulphate.—Crystallography of the cæsium-mercuric halides, by S. L. Penfield.—Silver hemisulphate, by M. C. Lea.—Restorations of Claosaurus and Ceratosaurus, by O. C Marsh.—Restoration of *Mastodon Americanus* (Cuvier), by the same.

THE number of the *Nuovo Giornale Botanico Italiano* for October is entirely occupied by the continuation of Sig. Nicotia's Statistics of the Flora of Sicily.

American Journal of Mathematics, vol. xiv., No. 3 (Baltimore, the John Hopkins Press, 1892).—The title of Prof. Cayley's communication, "Corrected Seminomiant tables for the Weights 11 and 12" (pp. 195–200) explains itself. It contains a better form of tables, which were given in a previous volume (vii., pp. 59–73). Weierstrass, in his memoir "Zur Funktionenlehre," called attention to certain functions, which offer special singularities. "Au lieu de présenter un nombre fini ou infini de points singuliers essentiels *isolés* elles offrent des lignes singulières essentielles ou même des *espaces lacunaires* à l'intérieur desquels elles cessent d'exister."—By request of Mr. Hermit, M. H. Poincaré discusses the subject in an article "Sur les fonctions à espaces lacunaires" (pp. 201-221).—J. C. Field, writes on "Transformation of a System of Independent Variables" (pp. 230–236).—Mansfield Merriman discusses "The deduction of final formulas for the Algebraic Solution of the Quartic Equation" (pp. 237–245), and L. S. Hulburt in remarks on "A class of new theorems on the number and arrangement of the real branches of plane Algebraic Curves" (pp. 246–250), follows up recent work, in the same direction, by Messrs. Harnack and Hilbert."—"The Symbolic notation of Aronhold and Clebsch" (pp. 251–261) has for its object the exposition of this notation, "so well adapted to the expression of functional invariants," in an English form. The same writer, W. F. Osgood, also contributes a note on "the System of two simultaneous Ternary Quadratic forms" (pp. 262-273). This, likewise, is a simplification for the benefit of English readers. It contains an account of Gordon's method, and employs the notation of the preceding article.—H. S. White communicates notes "on generating systems of Ternary and Quaternary Linear transformations" (pp. 274–282), and "a Symbolic demonstration of Hilbert's method for deriving Invariants and Covariants of given Ternary forms" (pp. 283–290). This latter paper also uses the symbolic notation of Aronhold and Clebsch in a simplified statement of recent results developed in Hilbert's notable paper "Ueber die Theorie der Algebräischen Formen" (Math.-Aca., vol. 36, pp. 524–6). The only paper, in the present number, which was read before the New York Mathematical Society is one by the President, Emory McClintock, "On the Computation of Covariants by Transvection" (pp. 222–229).

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 17.—M. Duchartre in the chair.—On Mr. Barnard's discovery of the fifth satellite of Jupiter, by M. F. Tisserand.—On the application of certain methods of successive approximation to ordinary differential equations, by M. Emile Picard.—On a reaction alleged to be peculiar to spermine, by M. Duclaux.—Observations of three new small planets discovered at the Nice observatory by means of photography, by M. Charlois; report by M. Perrotin (see Astronomical Column).—On the coexistence of dielectric power and electrolytic conductivity, by M. E. Bouty. A vindication of priority.—On the polarization of light of various colours by the atmosphere, by M. N. Piltschikoff. There is a well-marked difference between the intensity of polarization of blue light and that of red in the atmosphere The intensities are measured by